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Potassium Fertilization Effects on Cotton Lint Yield, Yield Components, and Reniform Nematode Populations

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ABSTRACT

Cotton (*Gossypium hirsutum* L.) lint yields have not changed appreciably during the last decade. Because more and higher infestations of reniform nematodes (*Rotylenchulus reniformis*) have been identified in mid-southern USA fields, this nematode might be a mitigating factor in the cotton yield stagnation. The objectives were to determine how varying rates of K fertilization interacted with different cotton genotypes to influence dry matter partitioning, lint yield, fiber quality, and reniform nematode populations. Nine cotton genotypes were grown in the field under two levels of K fertilization (0 and 112 kg K ha^{-1}) and two levels of aldicarb [2-methyl-2-(methylthio)propionaldehyde *O*-methylcarbamoyloxime] application (0 and 1.68 kg a.i. ha^{-1}) from 1999 through 2001. Reniform nematode numbers and aboveground dry matter partitioning were determined at various times in the growing season. Lint yield, yield components, and fiber quality were determined at the end of the season. Cotton grown with K fertilization hosted a 12% larger post-harvest population of reniform nematode than the unfertilized control plants. Plants grown without K fertilization averaged a 10% greater specific leaf weight than the K fertilized plants. Of the 9 genotypes grown, only PayMaster 1218BR increased lint yield (10%) in response to K fertilization. An interaction between aldicarb application and K fertilization for lint yield during the 2000 growing season indicated that both reniform nematode parasitism and insufficient K fertilization may impose limitations to lint yield production. Large reinform nematode populations may be suppressing the yield response to K fertilization. Production practices that encourage robust plant growth may enhance proliferation of existing reniform nematode populations.

In recent years, lint yields in the midsouthern portion of the U.S. cotton (*Gossypium hirustum* L.) production belt have become stagnant with little or no improvement as newer varieties have been adopted (Meredith, 2002). While this yield stagnation period has coincided with increased usage of transgenic cotton genotypes in the USA, recent research has indicated that at least some of the new transgenic cottons were not more susceptible to moisture deficit stress, in terms of yield, than their conventional cotton recurrent parents (Pettigrew, 2004). During this similar time frame, reniform nematodes (*Rotylenchulus reniformis*) have also become more entrenched as a serious economic pathogen in the Mississippi Delta (Koenning et al., 2004). This nematode was originally found in Mississippi in 1980 and by 2002 was estimated to infest >32.4% of the cotton hectarage in Mississippi (Lawrence et al., 2002). Although genetics is still probably the predominant reason for the lack of yield improvements, these higher field infestations of reniform nematodes may also be a mitigating factor.

The emergence of reniform nematodes as an economically challenging pathogen in cotton production has led to the desire to incorporate cotton genotypes resistant to reniform nematodes into current production schemes. While reniform nematode resistance exists in some of the diploid *Gossypium* species, no commercial cotton cultivars have yet been identified that possess reniform resistance (Koenning et al., 2004). While screening efforts of cotton cultivars have yet to detect resistance to reniform nematodes (Robinson et al., 1999), the number of commercial genotypes that could be screened at any one time is constrained by the logistics of the experiment. Some cotton germplasm lines have been identified that support statistically less nematode reproduction (Robinson et al., 2004). Most of these screening efforts utilized plants grown in pots inside greenhouses or growth chambers, with the resistance characterized by the ability of the nematodes to reproduce relative to that of a standard susceptible host (Koenning et al., 2004). Research quantifying how various aspects of plant growth and development are impacted by reniform nematode parasitism among a diverse group of cotton genotypes under field conditions is limited. Jones et al. (1959) reported that fumigation to suppress reniform nematode populations in field plots produced cotton yield increases, earlier maturity, and larger bolls. Lint percentage was inconsistently increased as a result of suppressing reniform nematodes in their research.

Following a period during the late 1980s and early 1990s when late season K deficiency symptoms could occasionally be observed in cotton production fields across the U.S. production belt, considerable research has been conducted on cotton K fertility during the past 15 yr. From this research, we have learned that because of decreased leaf photosynthesis (Bednarz and Oosterhuis, 1999), reduced leaf area index (Pettigrew and Meredith, 1997), and lower levels of solar radiation interception (Gwathmey and Howard, 1998), K deficiency can lead to reduced cotton lint yields and poorer fiber quality (Bennett et al., 1965; Cassman et al., 1990; Minton and Ebelhar, 1991; Pettigrew et al., 1996). One of the other interesting findings from this period of research is the fact that increased levels of root galling from the southern root-knot nematode (*Meloidogyne incognita*) were found on cotton plants grown under K-deficient condi-

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Abbreviations: DAP, days after planting; LAI, leaf area index; SLW specific leaf weight.

tions compared with adequate K conditions (Minton and Ebelhar, 1991). Presumably, the K-deficient conditions made the plants more susceptible to root-knot nematode attack. It has yet to be investigated whether K deficiency affects the susceptibility of cotton to reniform nematodes.

Because reniform nematodes are considered as an emerging problem in cotton production across the southeastern USA, most of the research directed toward this particular nematode in cotton has come in the past decade (Koenning et al., 2004). Thus, the effects that various management practices have on reniform nematode population densities have not been completely discerned. Therefore, the objectives of this research were to determine how two rates of K fertilization interacted with a diverse group of cotton genotypes to determine dry matter partitioning patterns, lint yield, fiber quality, and reniform nematode population densities. Two rates of aldicarb [2-methyl-2-(methylthio)propionaldehyde *0*-methylcarbamoyloxime] application were also imposed to assess the degree that parasitism by reniform nematodes affected cotton growth and development and lint yield production.

MATERIALS AND METHODS

Nine upland cotton genotypes were grown under two rates of annual K fertilization and two rates of aldicarb treatment. These field studies were conducted from 1999 through 2001 on a Beulah fine sandy loam (coarse-loamy, mixed, thermic Typic Dystrochrepts) near Stoneville, MS. Genotypes used in this study were 'DPL 32B', 'FiberMax 832', 'MD 51 ne', 'PayMaster 1218BR', 'Phytogen PSC 355', 'RGC 9811', 'Stv. BXN 47', 'Stv. La 887', and 'SureGrow 747'. These genotypes were chosen to represent a diversity of maturities, growth characteristics, and breeding programs. The DPL 32B and PayMaster 1218BR are trangenic varieties containing a gene from *Bacillus thuringiensis* that produces an endotoxin lethal to certain lepidopteran insects. PayMaster 1218BR also contains a gene that conveys resistance to the herbicide glyphosate [*N*-(phosphonomethyl)glycine]. The Stv. BXN 47 genotype is also a transgenic variety and contains a gene that conveys resistance to the herbicide bromoxynil. FiberMax 832 possesses the okra leaf-type trait. Both RGC 9811 (obtained from Roy G. Creech) and Stv. La 887 have some resistance to the southern root-knot nematode. The two rates of annual preplant K fertilization used in this study were 0 and 112 kg K ha^{-1} with KCl as the K source. These 0 kg K ha^{-1} plots were situated on areas that had not received K fertilization for a number of years and therefore were deficient in soil K levels, while the 112 kg K ha^{-1} plots were situated on areas that had annually received 112 kg K ha^{-1} (Minton and Ebelhar, 1991; Pettigrew et al., 1996; Pettigrew and Meredith, 1997). The aldicarb application rates were 0 and 1.68 kg a.i. ha^{-1}. For the 1.68 kg a.i. ha^{-1} treatment, half of the aldicarb was applied in-furrow at planting and the remaining half was applied as a side-dress application during the period of early square (fruiting bud) production. Aldicarb acts as a nematicide at the 1.68 kg a.i. ha^{-1} rate.

The experimental design was a randomized complete block having a split plot arrangement of treatments and six replicates. Potassium application rates and aldicarb application rates were arranged factorially to form the main plots. Subplots consisted of the genotypes. Treatments were randomly assigned to the plots in 1999 and remained in the same location thereafter to assess the effect of continued use of a genotype, aldicarb application, or K fertilization. Plots, consisting of four rows spaced 1 m apart and 5.3 m long, were planted 4 May 1999, 25 Apr. 2000, and 19 Apr. 2001. Plots were originally over-seeded and then hand thinned to a final population density of approximately 97 000 plants ha^{-1}. Recommended weed control methods were employed during each growing season as needed. Because aldicarb also exhibits insecticidal activity, plots were closely inspected for insect infestations. Whenever insects were observed approaching economic thresholds, other pesticides were applied to ensure no confounding effects from insects. Otherwise, all insects were controlled as needed during the growing season following recommended methods. The experimental area also received 112 kg N ha^{-1} in a preplant application and was furrow irrigated as needed during the growing season to minimize moisture stress.

Preplant soil samples were randomly collected from a 0- to 30-cm depth in all K fertility main plots during each year of the study. Samples were analyzed for K by Pettiet Soil Testing and Plant Analyses Lab., Leland, MS. The samples were extracted using the Mehlich 3 soil extract methodology (Mehlich, 1984) and elements determined using an inducely coupled argon plasma emission spectrophotometer.

Soil samples were also collected from the plots at planting, during the early bloom stage of growth, and after harvest to quantify the population density of reniform nematodes in the plots. At planting, samples were only collected from the K fertilization main plots. During early bloom and after harvest, soil samples were collected from the inner two rows of the individual plots. All the nematode samples from 1999 together with the planting and early bloom nematode samples from 2000 were processed by the University of Arkansas Nematode Diagnostic Clinic (Hope, AR). The after-harvest nematode samples in 2000 and all the 2001 nematode samples were processed by the Nematode Lab of the USDA-ARS Crop Genetics and Production Research Unit (Stoneville, MS). While the Arkansas lab extracted nematodes from 100 cm^3 of soil and the Mississippi lab extracted from 200 cm^3 of soil, both labs extracted the nematodes utilizing a semi-automatic elutriator followed by centrifugal flotation in 1 *M* sucrose solution.

Dry matter harvests were taken at 57 and 92 days after planting (DAP) in 1999, at 63 and 99 DAP in 2000, and at 68 and 104 DAP in 2001. The early dry matter harvest date roughly corresponded to the early blooming period, while the later harvest date corresponded to a cutout harvest date. Cutout refers to a period of slowing vegetative growth and flowering due to a strong demand for assimilates by the existing boll load. One of the inner two plot rows was designated for use in the dry matter harvests. On each harvest date, the aboveground portions of three plants from 0.3 m of row were harvested and separated into leaves, stems and petioles, squares, and blooms and bolls. Leaf area was determined using a LI-3100 leaf area meter (LI-COR, Lincoln, NE) and mainstem nodes were counted. Samples were dried for at least 48 h at 60°C, and dry weights were recorded. Harvest index was calculated as reproductive dry weight (squares, blooms, and bolls)/total aboveground dry weight.

At the end of each growing season, open bolls were hand harvested from one of the inner plot rows, previously designated as a harvest row. Two harvests and a subsample of 50 bolls were taken each year. The 50-boll sample was used to determine boll mass and then ginned to determine lint percentage. Lint yield was determined by multiplying the combined weight of the seed cotton from the two harvests and the 50-boll sample by the lint percentage. Boll mass was determined from the 50 boll sample by dividing weight of seed cotton by

Table 1. Preplant-extractable soil K concentration from plots that received annual applications of 0 or 112 kg K ha^{-1} in 1999 through 2001.

Year	K Fertilization	
	0 kg K ha^{-1}	112 kg K ha^{-1}
	mg kg^{-1} (±SE)	
1999	162 ± 4	245 ± 6
2000	116 ± 2	178 ± 4
2001	146 ± 10	218 ± 8

the number of bolls harvested. Boll number per unit ground area was back calculated from the total plot seed cotton weights and boll mass data. Lint from the 50 boll samples were sent to Starlab Inc. (Knoxville, TN) for the determination of fiber quality properties. Fiber strength and elongation were determined with a stelometer. Span lengths were measured with a digital fibrograph.

Statistical analyses were performed by analysis of variance (PROC MIXED; SAS Institute, 1996). Because the treatments and genotypes returned to the same field position each year, year was considered a repeated measure sub-subunit in a combined analysis over years. Genotype means, K means, and aldicarb means were averaged across years and each other when statistically important interactions were not detected. The nematode data were transformed ($\log_{10}$) before analysis. Geometric treatment or genotype means generated from back tranformed nematode data were separated by use of the least significant ratio (LSR) at $P \leq 0.05$. Treatment or genotype means from nontransformed data were separated by use of a protected LSD at $P \leq 0.05$.

RESULTS AND DISCUSSION

Preseason extractable soil K concentrations at a 0- to 30-cm depth were on average about 51% higher with the 112 kg K ha^{-1} treatment than without K fertilization (Table 1). Potassium deficiency symptoms were also sometimes visible in plots of the 0 kg K ha^{-1} during late August of each year. Extractable soil K levels <127 mg kg^{-1} are considered deficient for cotton production on this soil type in Mississippi. These K deficiency symptoms were due to the low initial soil K levels and the lack of added K fertilizer on the 0 kg K ha^{-1} treatment during the course of this experiment.

Reniform nematodes were distributed throughout the experimental area, as evidence by the fact that all the main plots contained nematodes in the samples taken at planting. However, Replicates 2 and 3 contained about 45% more nematodes than the other replicates (data not shown). Eighteen percent more vermiform reniform

Table 2. Number of vermiform reniform nematodes when sampled at planting as affected by K fertility treatments for the years 1999 through 2001, averaged across nine cotton genotypes.

K fertility	Year		
	1999	2000	2001
	nematodes L^{-1}		
0 kg K ha^{-1}	672†	5617	3664
112 kg K ha^{-1}	1761	5690	4671
LSR(0.05)‡	1.64	1.71	1.13
$P > F$	0.01	0.96	0.01

† Geometric means generated from back transformed ($\log_{10}$) data.
‡ Least significant ratio (LSR) utililzed as mean separation instead of LSD due to data transformation.

Table 3. Number of vermiform reniform nematodes when sampled at early bloom and post-harvest as affected by K fertility treatments and aldicarb application levels, averaged across nine cotton genotypes and the years 1999 through 2001.

K fertility	Aldicarb level	Early bloom	Harvest
		nematodes L^{-1}	
0 kg K ha^{-1}		2143†	10 334
112 kg K ha^{-1}		3373	11 697
LSR(0.05)‡		1.36	1.13
$P > F$		0.01	0.05
	0 kg ha^{-1}	4126	11 073
	1.68 kg ha^{-1}	1753	10 918
	LSR(0.05)	1.36	1.13
	$P > F$	0.01	0.81

† Geometric means generated from back transformed ($\log_{10}$) data.
‡ Least significant ratio (LSR) utilized as mean separation instead of LSD due to data transformation.

nematodes were found at planting in the soil from plots that received K fertilization than those that did not (Table 2). These nematode counts at planting were significantly greater 2 yr out of the 3 yr in the K-fertilized plots. The higher nematode populations with K fertilization at planting were also evident during the early bloom stage with 57% larger populations under K fertilization compared with the plots receiving no applied K (Table 3). By post-harvest, when the nematode populations in all plots were at their greatest, the K fertility treatment differences were still present, although the magnitude of the difference between them had decreased to the point that the plots receiving K fertilization had populations that were only 13% greater. This association of larger reniform nematode populations with K fertilization is inconsistent with the response of the southern root-knot nematode, which produced an increased level of root galling on cotton grown under K-deficient conditions (Minton and Ebelhar, 1991).

Application of aldicarb at a rate high enough to serve as a nematicide reduced the nematode population density at early bloom by 58% relative to the untreated control (Table 3). By post-harvest, the aldicarb was no longer present in the soil and the reniform nematode populations in the aldicarb-treated plots had recovered to levels similar to that of the untreated control.

The nematode reproduction in the various genotype plots was inconsistent across the two sampling growth stages (Table 4). During the early bloom stage of growth,

Table 4. Number of vermiform reniform nematodes when sampled at early bloom and post-harvest as affected by nine cotton genotypes averaged across K fertility treatments, aldicarb application levels, and the years 1999 through 2001.

Genotype	Early bloom	Harvest
	nematodes L^{-1}	
DPL 32B	2237†	11 219
FiberMax 832	1846	9 608
MD 51 ne	3561	10 981
PayMaster 1218BR	2270	10 451
Phytogen PSC 355	2321	11 743
RGC 9811	2975	10 480
Stv. BXN 47	2476	13 188
Stv. La 887	3232	11 315
SureGrow 747	3985	10 334
LSR(0.05)‡	1.92	1.16
$P > F$	0.32	0.01

† Geometric means generated from back transformed ($\log_{10}$) data.
‡ Least significant ratio (LSR) utililzed as mean separation instead of LSD due to data transformation.

Table 5. Cotton dry matter partitioning as affected by K fertility treatments and aldicarb application levels both early and late in the blooming period, averaged across nine cotton genotypes and the years 1999 through 2001.

Growth stage	K fertility	Aldicarb level	Height	Nodes	Leaf area index	Specific leaf wt.	Total dry wt.	Harvest† index
			cm	nodes plant^{-1}		g m^{-2}		
Early bloom	0 kg K ha^{-1}		70	15.2	2.06	59.5	255.1	0.038
	112 kg K ha^{-1}		69	15.2	2.13	54.4	248.8	0.040
	LSD(0.05)		4	0.3	0.13	2.4	11.1	0.006
	P > *F*		0.61	0.99	0.27	0.01	0.26	0.52
		0 kg ha^{-1}	70	15.3	2.04	56.3	245.6	0.037
		1.68 kg ha^{-1}	69	15.2	2.14	57.5	258.3	0.041
		LSD(0.05)	4	0.3	0.13	2.4	11.1	0.006
		P > *F*	0.72	0.26	0.10	0.33	0.03	0.20
Cutout	0 kg K ha^{-1}		117	21.7	3.94	53.3	829.6	0.371
	112 kg K ha^{-1}		118	21.6	4.26	48.6	812.6	0.346
	LSD(0.05)		3	0.7	0.40	2.4	65.7	0.017
	P > *F*		0.22	0.93	0.11	0.01	0.57	0.01
		0 kg ha^{-1}	117	21.8	4.04	50.4	788.1	0.348
		1.68 kg ha^{-1}	118	21.5	4.16	51.5	854.1	0.368
		LSD(0.05)	3	0.7	0.40	2.4	65.7	0.017
		P > *F*	0.33	0.39	0.51	0.35	0.05	0.03

† Harvest index = reproductive weight/total aboveground weight.

nematode counts did not differ among the nine genotypes. However, by the post-harvest sampling, the reniform nematode population density in the FiberMax 832 plots was significantly lower than those in the DPL 32B, Phytogen PSC 355, Stv. BXN 47, and Stv. La 887 plots. In addition, the Stv. BXN 47 plots hosted a greater post-harvest population of nematodes than all the other genotypes with the exception of Phytogen PSC 355. Interestingly, the genotype with the lowest nematode population density, FiberMax 832, is the only genotype not bred in the mid-southern region of the USA. It was developed in Australia and also is the only genotype to possess the okra leaf-type trait. The southern root-knot nematode resistance exhibited by RGC 9811 did not convey any appreciable resistance to the reniform nematode.

The most consistent dry matter partitioning trait affected by the two K fertility treatments was the specific leaf weight (SLW) (Table 5). During the early bloom dry matter harvest, leaves from the 0 kg K ha^{-1} had a SLW 9% greater than leaves in the K fertilized treatment. By cutout, this difference in SLW between K fertility treatments was still 10% greater for the plots not receiving K fertilization. This greater SLW in cotton plants not receiving adequate K fertilization is similar to results from other cotton K fertilization studies (Pettigrew and Meredith, 1997; Pettigrew 1999). Although numerically greater, the 112 kg K ha^{-1} fertilization rate did not increase the leaf area index (LAI) as has been reported in previous research (Pettigrew and Meredith, 1997; Pettigrew 2003). In addition to the greater SLW, during cutout the 0 kg K ha^{-1} plants exhibited a 7% greater harvest index relative to the K fertilized plants. This increased harvest index is most likely related to the earlier maturity of K-deficient cotton plants (Table 6), as has been reported by others (Gwathmey and Howard, 1998; Pettigrew, 2003).

Aldicarb also had an impact on the dry matter partitioning of the plants (Table 5). Cotton plants treated with 1.68 kg a.i.ha^{-1} aldicarb produced 5% more aboveground dry matter by early bloom and 8% more aboveground dry matter during cutout than the untreated control plants. Aldicarb-treated plants also partitioned more of the dry matter to reproductive growth as evidenced by the 6% greater harvest index at cutout.

A strong K × genotype interaction was observed for lint yield and percent first harvest across the 3 yr (Table 6). Paymaster 1218BR was the only genotype to produce additional lint in response to K fertilization; it produced 10% more lint yield with K fertilization. In previous studies at this same location utilizing different genotypes, all the genotypes increased lint yield production similarly in response to K fertilization (Pettigrew et al., 1996; Pettigrew, 1999, 2003). However, Cassman et al. (1989) also demonstrated genotypic differences in the response of cotton genotypes to K fertilization. Only FiberMax 832 and SureGrow 747 produced a significantly larger percentage of the their lint yield by the first harvest under the K-deficient conditions compared with the K-fertilized treatments. The other genotypes may not have shown this typical earlier maturity aspect of K-deficient conditions (Gwathmey and Howard, 1998; Pettigrew, 2003) because the initial harvest of these plots was delayed later than that of the previous studies, potentially wiping out any maturity differences. Potassium fertilization also produced minimal (1%) but statistically significant increases in lint percentage and boll mass relative to the unfertilized control. The number of bolls produced per unit area was not affected by K fertilization in this study.

For 1 yr out of the 3 yr of this study, there was a significant K × aldicarb interaction for lint yield. When aldicarb was applied to the plots at the nematicidal rate (1.68 kg a.i. ha^{-1}) in 2000, a positive lint yield response (6%) was observed when K fertilization was also applied to the plots (Table 7). Potassium fertilization produced this yield increase in these circumstances because it resulted in (6%) more bolls per unit ground area being produced. Furthermore, in the plots that were fertilized with 112 kg K ha^{-1} in 2000, the 1.68 kg a.i. ha^{-1} aldicarb treatment increased lint yield 12% relative to the untreated control. This aldicarb lint yield response was due to the production of 9% more bolls per unit ground area. There was not a significant K treatment × aldicarb

Table 6. Lint yield and yield components as affected by K fertility treatments and genotypes, averaged across aldicarb application levels and the years 1999 through 2001.

K fertility	Genotype	Lint yield	% First harvest	% Lint	Boll mass	Boll no.
		kg ha^{-1}	%		g boll^{-1}	bolls m^{-2}
0 kg K ha^{-1}	DPL 32B	1283	82.9	36.5	4.59	78
	FiberMax 832	1058	76.9	37.4	5.43	53
	MD 51 ne	1004	81.4	35.3	4.87	59
	PayMaster 1218BR	1241	88.6	39.4	5.35	60
	Phytogen PSC 355	1268	85.3	39.0	4.55	73
	RGC 9811	1078	84.8	35.9	4.78	64
	Stv. BXN 47	1229	83.5	39.2	4.47	71
	Stv. La 887	1153	77.5	37.7	5.49	57
	SureGrow 747	1332	87.4	39.0	5.09	69
112 kg K ha^{-1}	DPL 32B	1265	79.9	37.0	4.63	75
	FiberMax 832	1068	72.6	37.6	5.57	52
	MD 51 ne	1013	80.7	35.8	4.84	60
	PayMaster 1218BR	1370	88.8	39.9	5.47	63
	Phytogen PSC 355	1249	86.0	39.2	4.58	71
	RGC 9811	1032	83.2	36.3	4.78	61
	Stv. BXN 47	1181	83.8	39.4	4.52	67
	Stv. La 887	1115	76.1	38.1	5.42	55
	SureGrow 747	1343	83.6	39.6	5.20	66
LSD(0.05) genotypes within K levels		60	2.5	0.4	0.10	3
LSD(0.05) genotypes across K levels		74	3.1	0.4	0.10	4
0 kg K ha^{-1} treatment mean		1183	83.1	37.7	4.96	65
112 kg K ha^{-1} treatment mean		1182	81.6	38.1	5.00	63
K treatment $P > F$		0.95	0.15	0.01	0.04	0.23
K × Genotype $P > F$		0.01	0.03	0.41	0.05	0.10

treatment interaction for either of the remaining yield components measured.

Few fiber quality traits were significantly affected by either K fertility treatments or the aldicarb application treatments (Table 8). The exception to this generalization is that aldicarb application reduced the fiber 50% span length by 1% relative to the untreated control. In addition, the 1% increase in fiber micronaire and 3% increase in fiber elongation produced by K fertilization were statistically significant at the $P \leq 0.07$ level. None of the other fiber traits were affected by either K fertilization or aldicarb.

The higher population densities of reniform nematodes found in cotton that had received 112 kg K ha^{-1} relative to the cotton not receiving K fertilization (Table 2) has not been previously demonstrated. In lieu of the greater root gall index caused by southern root-knot nematodes previously found in cotton grown under low K conditions (Minton and Ebelhar, 1991), it was somewhat surprising to find greater reniform nematode counts in soil that had been fertilized with K. However, there is precedence for greater nematode numbers in response to fertilization in other plant species. Luedders et al. (1979) found that the number of cysts on the roots of pot-grown soybean [*Glycine max* (L.) Merr.] plants caused by the soybean cyst nematode (*Heterodera glycines* Ichinohe) initially increased with lower rates of K fertilization before declining at the higher fertilization rates. Presumably, the reduction in cyst numbers at the high K rates was due to an apparent salt effect. In con-

Table 7. Lint yield and yield components as affected by K fertility treatments and aldicarb application levels for the years 1999 through 2001.

K fertility	Aldicarb level	Lint yield	% First harvest	% Lint	Boll mass	Boll no.
		kg ha^{-1}	%		g boll^{-1}	bolls m^{-2}
			1999			
0 kg K ha^{-1}	0 kg ha^{-1}	1207	65.9	37.6	4.31	75
	1.68 kg ha^{-1}	1195	71.3	37.0	4.39	74
112 kg K ha^{-1}	0 kg ha^{-1}	1120	65.1	37.7	4.40	68
	1.68 kg ha^{-1}	1219	69.1	37.5	4.50	73
LSD(0.05)†		94	5.8	0.5	0.11	5
K × aldicarb $P > F$		0.09	0.72	0.24	0.73	0.11
			2000			
0 kg K ha^{-1}	0 kg ha^{-1}	1184	87.5	35.0	5.14	66
	1.68 kg ha^{-1}	1185	89.3	35.0	5.25	65
112 kg K ha^{-1}	0 kg ha^{-1}	1126	88.4	35.0	5.12	63
	1.68 kg ha^{-1}	1262	84.6	34.8	5.26	69
LSD(0.05)		63	4.2	0.3	0.09	3
K × aldicarb $P > F$		0.01	0.07	0.23	0.62	0.01
			2001			
0 kg K ha^{-1}	0 kg ha^{-1}	1138	92.0	40.8	5.30	53
	1.68 kg ha^{-1}	1190	92.7	40.9	5.36	55
112 kg K ha^{-1}	0 kg ha^{-1}	1176	90.6	41.8	5.34	53
	1.68 kg ha^{-1}	1188	91.9	41.8	5.39	53
LSD(0.05)		96	1.3	0.2	0.07	4
K × aldicarb $P > F$		0.56	0.50	0.72	0.89	0.58

† LSD is for the K × aldicarb interaction within that particular year.

Table 8. Various cotton fiber quality traits as affected by K fertility treatments and aldicarb application levels, averaged across the years 1999 through 2001.

K fertility	Aldicarb level	Fiber micronaire	Fiber elongation	Fiber strength	Span length		Length uniformity†
					2.5%	50%	
			%	kN m kg^{-1}	cm		%
0 kg K ha^{-1}		4.40	7.2	211	2.90	1.45	49.9
112 kg K ha^{-1}		4.46	7.4	210	2.91	1.44	49.7
LSD $_{0.05}$		0.07	0.2	2	0.01	0.01	0.4
$P > F$		0.07	0.07	0.16	0.42	0.39	0.24
	0 kg ha^{-1}	4.44	7.3	210	2.91	1.45	50.0
	1.68 kg ha^{-1}	4.42	7.2	211	2.90	1.44	49.7
	LSD(0.05)	0.07	0.2	2	0.01	0.01	0.4
	$P > F$	0.44	0.46	0.96	0.44	0.03	0.14

† Length uniformity = (50% span length ÷ 2.5 % span length) × 100.

trast, Hanson et al. (1988) did not find any difference in counts of soybean cyst nematode cysts between K treatments in field-grown soybean plants. A speculative explanation for the increased reniform nematode populations found in cotton receiving K fertilization is that the additional K resulted in a more robust plant with a more extensive root system. This more extensive root system might provide more sites for feeding and reproduction of the reniform nematodes and thus result in the larger population densities observed.

Genotypic differences were demonstrated in the postharvest reniform nematode counts, with FiberMax 832 supporting the lowest population density of nematodes at 9608 nematodes L^{-1} soil (Table 4). While these genotypic differences were statistically significant, the nematode population densities of all the genotypes hovered near or exceeded the economic threshold for Mississippi of 10 550 nematodes L^{-1} soil. Therefore, it is questionable whether these observed genotypic differences would prove meaningful or useful as a source of possible resistance.

Normally at this experimental site, cotton grown on the areas that had not received any K fertilization over the years was fairly consistent in exhibiting a reduction in LAI and lint yield (Pettigrew and Meredith, 1997; Pettigrew, 1999, 2003). However, the K fertility response for lint yield in this study was not as consistent. When averaged across aldicarb levels and years, a yield increase due to K fertilization was observed for only one out of the nine genotypes. In 2000, aldicarb had to be applied at the 1.68 kg a.i. ha^{-1} rate for lint yield to respond favorably to K fertilization (averaged across genotypes). This K fertilization response was not produced without the aldicarb application that year and was not observed in any form in either 1999 or 2001. In addition, to achieve a lint yield increase in 2000 from the aldicarb application, the plots also needed to be fertilized with K.

One interpretation of the lint yield data is that either reniform nematodes or insufficient K was limiting the yields in plots that did not receive either the aldicarb treatment or K fertilization, respectively. For an aldicarb treatment to produce a lint yield increase in cotton, any insufficient soil K level must be corrected. Conversely, nematode infestations must be controlled for cotton to achieve the optimal benefits from K fertilization. One caveat to these interpretations is that because aldicarb also has insecticidal activities, we cannot rule out that an insect was the yield limiting pest controlled by aldicarb, rather than the reniform nematodes. However, whenever any insect was observed approaching economic thresholds, other pesticides were applied for control.

In conclusion, elevated populations of reniform nematodes were detected in plots that had received annual applications of 112 kg K ha^{-1} throughout the years. It appears that, in theory, the more robust plants grown under adequate K fertilization may have a larger root system capable of hosting a larger reproducing population of reniform nematodes. None of the genotypes evaluated in this study appear to offer a useful level of resistance to the reniform nematode. Because of this lack of useful resistance in commercial genotypes, producers should be aware that production practices that support robust plant growth may also encourage the proliferation of reniform nematodes in certain soil types if they are already present in the field.

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